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ABSTRACT

Described in this pamphlet is a procedure used by the West Virginia Air Pollution Control Commission to train personnel in evaluating visible emissions. For this purpose a "Smoke Observer's Training Unit" has been designed, a machine capable of generating both gray/black plumes for training in the use of Ringlemann readings and white plumes for training to "read" the densities of plumes other than gray/black. Procedures for using the equipment are explained together with how the training should be conducted regarding reading techniques and actual reading practice. Forms for recording visual readings of both kinds of plumes as used in the training process are included. Also stated are certification requirements. (BL)

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INTRODUCTION

Many types of emissions to the atmosphere are visible to the naked eye at or near the point of discharge. Consequently it has long been the practice of governmental regulatory air pollution control agencies to incorporate into their legally enforceable standards a limitation or limitations on such visible emissions. Regulations promulgated by the Commission to date which include limitations on visible emissions are given in the following table:

Regulation II	To Prevent and Control Particulate Air Pollution from Combustion of Fuel in Indirect Heat Exchangers.
Regulation III	To Prevent and Control Air Pollution from the Operation of Hot-Mix Asphalt Plants.
Regulation V	To Prevent and Control Air Pollution from the Operation of Coal Preparation Plants and Coal Handling Operations.
Regulation VI	To Prevent and Control Air Pollution from Combustion of Refuse
Regulation VII	To Prevent and Control Air Pollution from Manufacturing Process Operations

TYPES OF VISIBLE EMISSION STANDARDS

The following two methods are used to evaluate the visible properties of a plume:

(1) The Ringlemann chart is used as a comparison standard against which the "shade" of gray/black plumes are

determined. Technically the chart gives the density (to transmitted light) of gray/black plumes in five equal steps between white and black (0, 1, 2, 3, 4, 5).

(2) The "Equivalent Opacity Determination" is used to determine the densities (to transmitted light) of plumes which are not a shade of gray. Equivalent opacity determinations are expressed directly in "percent of opacity" (0%, 20%, 40%, 60%, 80%, 100%).

Readings of Ringlemann numbers can be made to fractions between the whole numbers given above and readings of opacity can also be made to percents between the numbers given above by trained personnel.

Determination of a plume's Ringlemann number or equivalent opacity (whichever may be applicable to the plume in question) is done by using qualified field personnel who have been specially trained and certified to visually make such determinations in an objective manner and without the use of field equipment.

TRAINING EQUIPMENT

The training method used by the West Virginia Air Pollution Control Commission incorporates a "Smoke Observer's Training Unit" designed for this purpose. This machine shown in schematic form in Figure 1 is capable of generating both gray/black plumes for training in the use of Ringlemann readings and white plumes for training to "read" the densities of plumes other than gray/black. As both types of determinations depend basically on the degree of

obscuration to transmitted light the unit is equipped with a constant light source and a photoelectric cell-meter system capable of very accurately recording the amount of light transmitted by the light source through the generated plumes. The meter has two scales, one for Ringlemann numbers and one for percents of opacity. Meter readings for various density plumes can then be compared with simultaneous visual observations taken by observers at the point of emission of the plume from the stack exit.

TRAINING PROCEDURE

The initial step of the training session consists of an instructor familiarizing the trainees with known densities of both gray/black and white plumes. This is done by emitting gray/black plumes of varying Ringlemann numbers from the training unit and calling out the Ringlemann readings shown on the meter for each density plume. Similarly, white plumes are generated and the meter reading (in percent opacity) is called out for each such plume. This procedure is repeated until the trainees are able to generally recognize the various Ringlemann or opacity readings.

The formalized training then follows the above familiarization. The training consists of a series of "runs" for gray/black plumes and a series of "runs" for white plumes. A "run" consists of the instructor randomly producing 25 plumes of different densities. The meter reading for each plume is then recorded by the instructor and the trainees are signaled to make their visual reading of the plume

and record it on forms which have been provided. The training form for gray/black readings is shown in Figure 2 and the form for white readings is shown in Figure 3. At the end of the 25 readings the instructor calls off the actual meter reading for each plume and the trainees record these on their forms. The differences between the trainee's readings and the meter readings are then calculated and appropriate computations including percentages of deviation are calculated. The trainee must complete 16 runs of gray/black (400 readings) and 16 runs of white (400 readings) prior to final testing for certification. The meter on the training unit is calibrated at a minimum after each run but may be calibrated more frequently, if necessary.

In addition to the reading practice the trainees are instructed in the proper reading techniques. The most important of these are as follows:

(1) The observer should never look directly into bright sunlight. He should be positioned with the sun directly at his back if possible or as near to his back as reasonably practical. In cloudy weather the position of the sun is relatively unimportant. The background should be free of buildings or other distracting objects.

(2) The observer's observation line should be at right angles to the direction of plume travel.

(3) Readings should be made at the point where the plume is approximately the same diameter as the stack (Generally at the point of emission from the stack). For steam containing plumes, readings should be taken immediately beyond the point where the steam dissipates.

(4) Most observers will read more accurately if they do not "study" the plumes but rather use a quick trained glance.

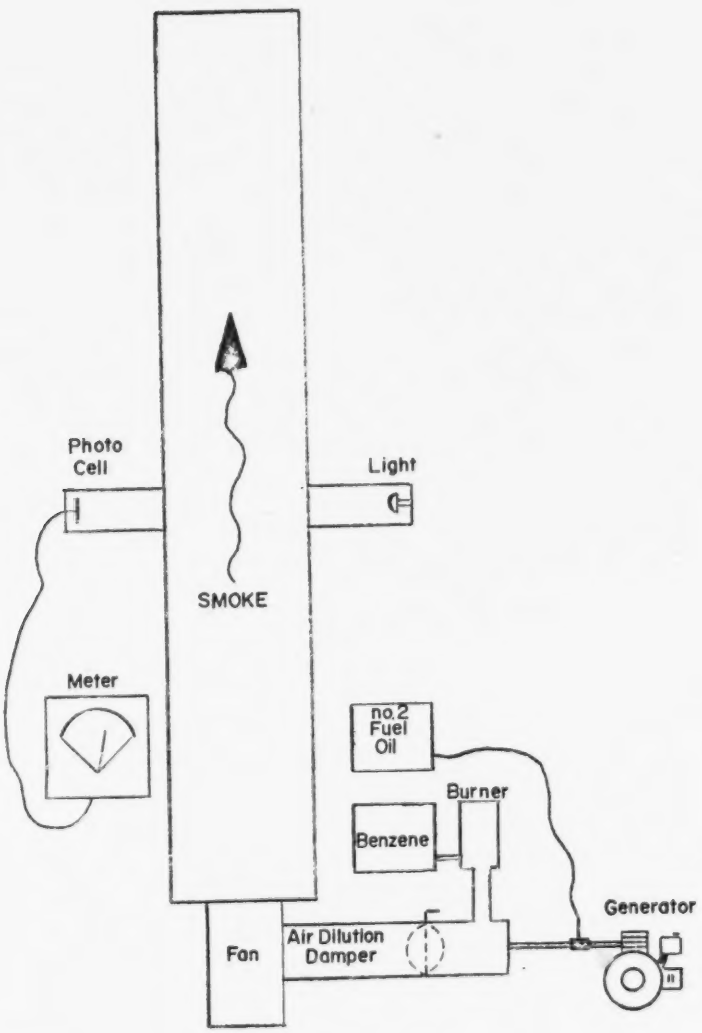
CERTIFICATION PROCEDURE

After the above instructions and 800 formal training readings a trainee is ready to take the certifying proficiency test. This test consists of 25 gray/black plumes and 25 white plumes.

To be certified as an observer of gray/black plumes a trainee must be able to assign, with demonstrated consistency, Ringelmann numbers to the nearest quarter of a Ringelmann number to the 25 different gray/black plumes with an error not to exceed 15% on any one reading and an average error not to exceed 7.5% on all 25 readings. All certified observers must be able to pass this test every six (6) months in order to be recertified.

To qualify as an observer of plumes which are other than gray/black (i.e., opacity determinations) the trainee must be able to assign opacity readings, with demonstrated consistency, in 5% increments to the 25 different white plumes with an error not to exceed 15% on any one reading and an average error not to exceed 7.5% on all 25 readings. All certified observers must be able to pass this test every six (6) months in order to be recertified.

FIGURE 1 - SCHEMATIC OF SMOKE OBSERVATION TRAINING UNIT



Benzene is burned to generate black smoke.

No. 2 fuel oil is vaporized to generate white smoke.

TABLE I

INSTRUCTIONS FOR COMPLETING TRAINING FORMS
(Figures 1 and 2)

1. Enter readings in columns 1, 2, 4 and 5 in Ringlemann numbers or fractions only. Do not enter them decimally. Enter fractions no less than $\frac{1}{4}$.

2. Enter readings in columns 7, 8, 10 and 11 in percent opacity from 0 to 100 by 5's or 10's.

3. Enter deviations in columns 3 and 6 in percent only, i. e., one R deviation = 20%, $\frac{1}{4}$ R deviation = 5%, etc. In columns 9 and 12 simply enter percent difference between columns 7 and 8 or 10 and 11.

4. If your reading is less than the meter reading enter the deviation as minus. If it is greater enter the deviation as plus.

Figure 2: TRAINING FORM FOR GRAY/BLACK PLUMES

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RUN NO. _____

BLACK READINGS

	1	2	3		4	5	6
Reading No.	Observer Reading	Meter Reading	Deviation	Reading No.	Observer Reading	Meter Reading	Deviation
1				15			
2				16			
3				17			
4				18			
5				19			
6				20			
7				21			
8				22			
9				23			
10				24			
11				25			
12				No. of Correct			
13				No. of Plus			
14				No. of Minus			

Sum of Plus Deviations _____

Number of Plus Deviations _____

Average Plus Deviation = $\frac{\text{Sum of Plus Deviations}}{\text{No. Plus Deviations}}$

_____ %

Sum of Minus Deviations _____

Number of Minus Deviations _____

Average Minus Deviation

2				16			
3				17			
4				18			
5				19			
6				20			
7				21			
8				22			
9				23			
10				24			
11				25			
12				No. of Correct			
13				No. of Plus			
14				No. of Minus			

Sum of Plus Deviations _____

Number of Plus Deviations _____

Average Plus Deviation = $\frac{\text{Sum of Plus Deviations}}{\text{No. Plus Deviations}}$

_____%

Sum of Minus Deviations _____

Number of Minus Deviations _____

Average Minus Deviation = $\frac{\text{Sum of Minus Deviations}}{\text{No. of Minus Deviations}}$

_____%

Percent of Readings 10% Deviation and under _____%

Day_____ Night_____ Light Location_____

Briefly Describe Weather Conditions and Background _____

_____

_____

Figure 3. TRAINING FORM FOR WHITE PLUMES

RUN NO._____

WHITE READINGS							
	7	8	9		10	11	12
Reading No.	Observer Reading	Meter Reading	Deviation	Reading No.	Observer Reading	Meter Reading	Deviation
1				15			
2				16			
3				17			
4				18			
5				19			
6				20			
7				21			
8				22			
9				23			
10				24			
11				25			
12				No. or Correct			
13				No. of Plus			
14				No. of Minus			

Sum of Plus Deviations _____

Number of Plus Deviations _____

Average Plus Deviation = $\frac{\text{Sum of Plus Deviations}}{\text{No. Plus Deviations}}$

_____ %

Sum of Minus Deviations _____

3				17			
4				18			
5				19			
6				20			
7				21			
8				22			
9				23			
10				24			
11				25			
12				No. or Correct			
13				No. of Plus			
14				No. of Minus			

Sum of Plus Deviations _____

Number of Plus Deviations _____

Average Plus Deviation = $\frac{\text{Sum of Plus Deviations}}{\text{No. Plus Deviations}}$

_____%

Sum of Minus Deviations _____

Number of Minus Deviations _____

Average Minus Deviations $\frac{\text{Sum of Minus Deviations}}{\text{No. Minus Deviations}}$

_____%

Percent of Readings 10% Deviation and under _____%

Day _____ Night _____ Light Location _____

Briefly Describe Weather Conditions _____

_____

_____